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# The Impact of the Next Generation Internet (NGI) on Naval Engineering

## ABSTRACT

Naval Engineering will be greatly impacted by the emergence and deployment of the Next Generation Internet (NGI) based upon the Transmission Control Protocol / Internet Protocol version 6 (TCP/IPv6) family of protocols. Shipboard Information Technology (IT), IT for the 21st Century (IT-21), the Navy and Marine Corp Intranet (NMCI), and the commercial Internet currently are built upon the Transmission Control Protocol / Internet Protocol version 4 (TCP/IPv4) family of protocols. The TCP/IPv6 protocol family will likely replace the TCP/IPv4 protocol family after an extended transition period, anticipated at up to 10 years, during which both protocol families will need to be supported. The replacement of the TCP/IPv4 protocol family is necessary to ensure the long-term health, scalability, and security of the Internet and DoD Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR). The USN, USMC, and DoD should begin preparing for this costly and complex transition.

## Introduction

In the aftermath of the Y2K bug, an equally significant event is beginning to quietly unfold. The Internet as we know it is being replaced by the Next Generation Internet (NGI*). The replacement is expected to share many of the characteristics of the Y2K bug yet present its own problems too. It may eventually cost humanity up to ten times the cost of Y2K or $6 trillion US dollars![1] A large percentage of this cost will fall on the United States (US) since the US has the largest installed base of TCP/IPv4 in the world. Naval engineering needs to be aware of and begin planning for this replacement since the design, analysis, operation, and life cycle costs of ships is directly dependent on the Internet Protocol (IP) standards and Information Technology (IT) in general.

## What is the Internet?

The Internet is a global network of networks enabling computers of all kinds to directly and transparently communicate and share services throughout much of the world. Because the Internet is an enormously valuable, enabling capability for so many people and organizations, it also constitutes a shared global resource of information, knowledge, and means of collaboration, and cooperation among countless diverse communities.

End-to-end interoperability is achieved by adherence to an evolving, collaboratively developed and tested set of protocol specifications collectively called the Internet Protocol (IP) standards. The Internet Engineering Task Force (IETF) develops these specifications. The Internet Engineering Steering Group (IESG) then considers the specifications for standardization, with appeal to the Internet Architecture Board (IAB). Finally, the Internet Society (ISOC) propagates the IP specifications as international standards. The standards may be found at numerous sites distributed throughout the world such as http://www.ietf.org. The current IP standard specifications are collectively known as TCP/IPv4 or simply TCP/IP.

Figure 1 illustrates a notional diagram of the Internet. It demonstrates that the Internet is a collaboration of interconnected Intranets and
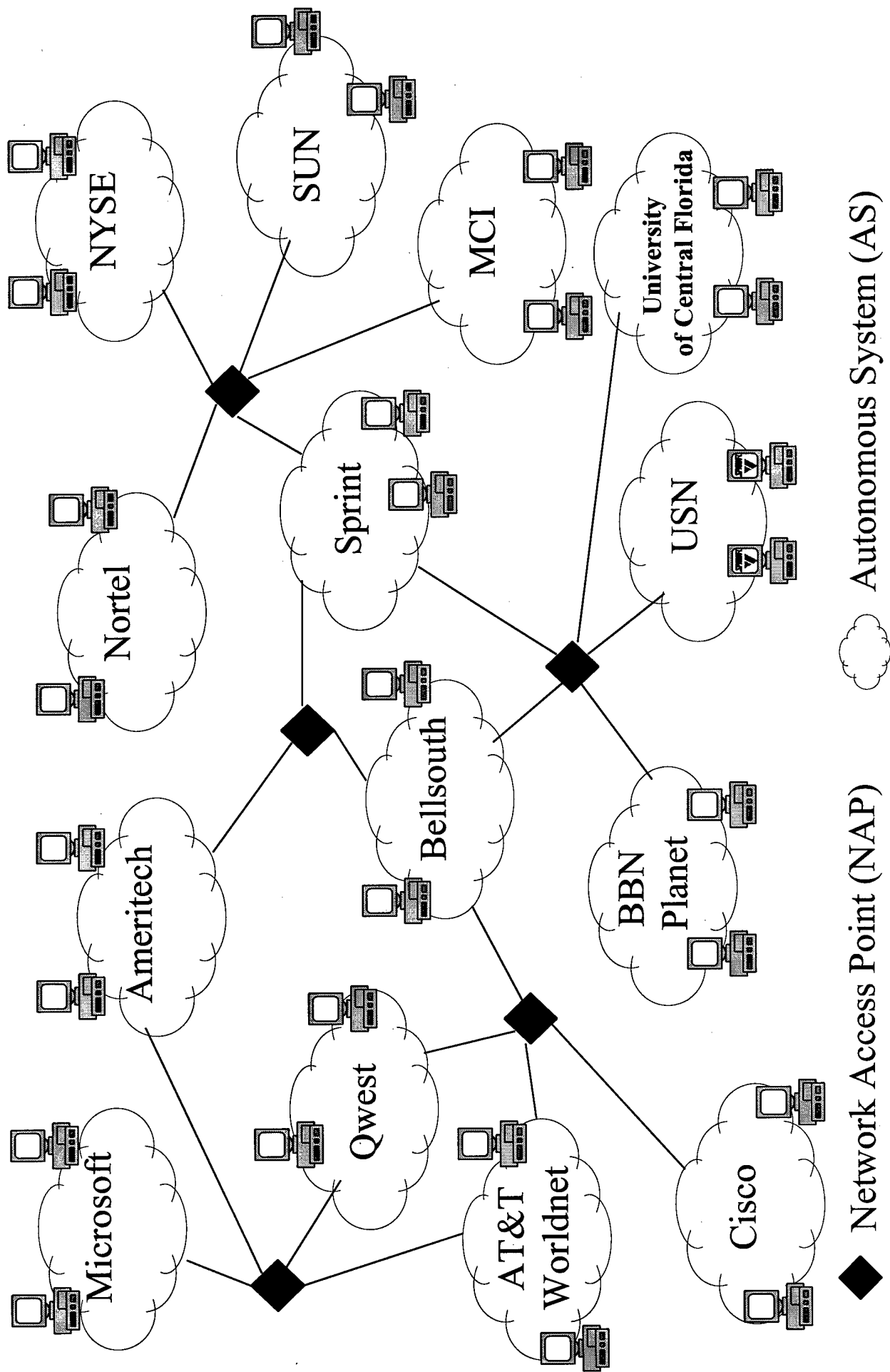
**Figure 1. Notional Diagram of the Internet**

Autonomous System (AS)

Network Access Point (NAP)

NYSE

SUN

MCI

University
of Central Florida

Sprint

USN

Nortel

Bellsouth

BBN
Planet

Ameritech

Qwest

Microsoft

AT&T
Worldnet

Cisco

Internet Service Providers (ISPs). No single organization owns the entire Internet but Autonomous Systems (ASs) or networks are owned by individual government, commercial, and educational organizations. The diagram is notional since the connectivity demonstrated is not necessarily accurate. In addition, the Internet is in constant growth and change. Providing an accurate diagram of the Internet is nearly impossible for these reasons.

## History of the Internet.

The TCP/IPv4 family of protocols were initially developed from the early 1970s by the U.S. Department of Defense (DoD) Defense Advanced Research Projects Agency (DARPA) as a robust means of interconnecting the data communications of military sites. The Internet evolved principally in the research and education communities in the eighties until the US federal government allowed commercial access to it in 1991. Shortly thereafter, the US federal government began transferring control and management of the Internet from the DoD to the ISOC and Internet Assigned Numbers Authority (IANA). After 1991, the Internet and the TCP/IPv4 protocol family became the defacto standard as nearly everyone around the world adopted it to utilize email, the World Wide Web (WWW), and other Internet based applications. The commercialization of the Internet was recently completed with the incorporation of the not for profit Internet Corporation for Assigned Names and Numbers (ICANN). ICANN has assumed the Internet name delegation authority of the US federal government and in the near future will absorb the Internet number and address assignment functions of IANA.

## How Big is the Internet?

According to Telecordia's Netsizer service; http://www.Netsizer.com, the number of computers communicating via the Internet is approaching 80 million. This number is growing at roughly 20,000 computers per day and rapidly accelerating. The total number of computers utilizing the TCP/IPv4 family of protocols is actually much greater than just the number of computers communicating via the Internet. Additional millions of computers utilize the TCP/IPv4 family of protocols for communicating via private corporate and organizational Intranets not directly connected to the Internet. Two excellent examples of private Intranets are the US DoD Secret IP Routed Network (SIPRNET) and Unclassified But Sensitive Internet Protocol Routed Network (NIPRNET).

## How Many People Use the Internet?

Worldwide, the number of people on-line; that is using the Internet, is quoted at over 300 million.[2] This number is also growing rapidly. Expectations are that over 3 billion people will be on-line by the year 2047. This only represents about 25% of the projected world population.

Today, roughly a 4:1 ratio exists between the number of people on-line and the number of Internet connected computers. In the near future, this ratio is likely to approach 1:1 and then 1:>1 as more and more inexpensive information appliances come to market. Industry sees a huge, largely untapped market for information appliances since many people perceive today's computer technology as being too complex and user-unfriendly.

## What is the Value of Internet Based Electronic Commerce?

The value of electronic commerce (E-commerce) over the Internet is projected to grow to between $1.8 and $3.2 trillion US dollars per year by 2003.[2] This is with only 5%-8% of the earth's population online! E-commerce could easily grow to many multiples of this in a very short time. The

potential market value of the Internet and E-commerce is relatively clear. The long-term social, political, cultural, and military ramifications of the Internet are not as clear. The Internet is revolutionary to the human race and human experience. It will affect every facet of our lives just as the transportation, industrial, aerospace, and computer revolutions have in the recent past.

## The Internet is a Victim of it's Own Success.

The Internet has become a victim of its own phenomenal success since the TCP/IPv4 family of protocols was never designed to support such a large network. In the early 1990's, the IETF became concerned with the rate at which IPv4 addresses were being consumed in a critical "class" of addresses, class B, and the explosive growth of routing tables in Internet backbone routers. This concern led the IETF to begin designing a successor to the TCP/IPv4 protocol family. At the same time, the IETF began to upgrade the TCP/IPv4 protocol family so the Internet could survive and grow until its successor was ready for deployment.

The successor was initially known as TCP/IPng and today the TCP/IPv6 family of protocols. The TCP/IPv6 protocol family is expected to support high performance internetworking into the 21$^{st}$ century. It is anticipated to do so because of its efficiency, robustness, and since it provides the additional addresses needed to support the NGI's anticipated growth.

## NGI is Expected to be a Major Improvement over the Internet

The NGI will incorporate a number of important enhancements over the present Internet. For example, the TCP/IPv6 family of protocols:

- ◆ Includes mandatory authentication and encryption features that will improve the security of the NGI

over that available on the current Internet.

- ◆ Provides a huge pool of addresses, giving billions of new devices "always on" connectivity with the NGI.

- ◆ Supports host self-configuration, thus simplifying and reducing the support costs of maintaining the NGI.

- ◆ Incorporates features supporting mobile connectivity with the NGI.

- ◆ Includes Quality of Service (QoS) features enabling concurrent and prolific voice, video and data communication over the NGI.

- ◆ Restores the simplicity, robustness, flexibility, manageability, fault tolerance and responsiveness, which were the principal reasons for the current Internet's explosive growth and almost universal acceptance.

## Transition from Internet to NGI is Already in Progress

Creating the NGI, from the current Internet, will be a huge, complex, and likely lengthy task. The IETF recognized the magnitude of this from the beginning. The IETF knew it will be impossible to transition the Internet to the NGI at one instant in time. Some experts in the IETF have predicted the process could take up to 10 years. To support a graceful transition, the IETF designed special features into the TCP/IPv6 protocol family. These special features or transition mechanisms are necessary because the TCP/IPv4 and TCP/IPv6 protocol families have only "limited" interoperability. The first, referred to as the "Dual Stacking Transition Mechanism (DSTM)", involves operating both the TCP/IPv4 and TCP/IPv6 protocol families on each machine. The second, referred to as

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the "Tunneling Transition Mechanism (TTM)", involves interconnecting networks utilizing one protocol family with connections embedded in the infrastructure of the other protocol family. Computers using the TCP/IPv6 protocol family can communicate with each other by tunneling through networks using the TCP/IPv4 protocol family. Likewise, Computers using the TCP/IPv4 protocol family can communicate with each other by tunneling through networks using the TCP/IPv6 protocol family. The third, referred to as "Network Address Translation (NAT)", involves application layer protocol translation between the two protocol families.

The transition from Internet to NGI actually has begun already. The 6BONE is a testbed internet set up to assist in the evolution and deployment of the TCP/IPv6 protocol family. It is built upon, and tunneled through, the TCP/IPv4 Internet. It currently consists of over 200 sites in 39 nations. The IPv6 Research and Education Networks (6REN) is an internet utilizing only the TCP/IPv6 protocol family and provides production TCP/IPv6 services worldwide. On July 14, 1999 the Internet Assigned Numbers Authority (IANA) began delegating the initial IPv6 address space to the Regional Internet Registries (RIRs) in order to begin immediate worldwide deployment of IPv6 addresses. This was a major step in the transition from Internet to NGI. With this, the NGI can now begin to offer commercial services to the general public, government, industry, and the military.

# Now is the Time for DoD to Prepare.

DoD Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and IT are heavily dependent on the TCP/IPv4 family of protocols. Major USN and USMC programs based upon TCP/IPv4 include IT for the

twenty-first century (IT-21), the Navy and Marine Corp Intranet (NMCI), Base Level Information Infrastructure (BLII), Automated Digital Network System (ADNS) and the Marine Corp Enterprise Network (MCEN). The TCP/IPv4 family of protocols is throughout the USN fleet and likely is within each of our ships. The TCP/IPv4 protocol family likely interconnects each of our bases with each other and with the fleet. The TCP/IPv4 protocol family is the foundation upon which "stovepipes" were eliminated from USN and USMC communications. It is a pillar upon which the communications components of the Defense Information Infrastructure / Common Operating Environment (DII/COE) have been built.

Many questions must still be asked and resolved before the USN and USMC can fully benefit from the NGI. The analysis must begin soon to provide the answers to these questions. Which method or combination of methods should the USN, USMC, and DoD utilize? How large of an IPv6 address block should the USN and USMC request from our RIR, the American Registry for Internet Numbers (ARIN)? Should the USN and USMC be delegated IPv6 address blocks from DISA? How should IPv6 address block requests be coordinated between the military services to ensure optimal routing performance in the future NGI? Many components of the Internet's infrastructure must be upgraded, such as Domain Naming System (DNS) servers and routers. What are the best methods for upgrading the infrastructure without degrading current services? How will DoD's software applications, which are built upon the TCP/IPv4 protocol family, port to the TCP/IPv6 protocol family and then be enhanced to take advantage of advanced TCP/IPv6 features? This transition issue could mirror Y2K and be the most costly component of the NGI deployment. The DoD should consider how it will address these and many other questions while there is still time to minimize the cost of this huge and complex task.

## Conclusions

The effects of migrating to the TCP/IPv6 family of protocols will be profound. Near term implications include:

(1) Increased complexity and cost of designing shipboard networks to support both the TCP/IPv4 and TCP/IPv6 protocol families.

(2) Increased shipboard IT administration, manning, and training.

(3) Increased cost and complexity associated with blending military and commercial security paradigms.

(4) Increased cost and resources required to upgrade, test, and integrate application software to support the TCP/IPv6 family of protocols.

(5) Increased cost and complexity associated with upgrading network infrastructure.

Long term benefits of transitioning from the TCP/IPv4 protocol family to the TCP/IPv6 protocol family include:

(1) Utilization of militarized commercial Multi-Level Security (MLS) for higher levels of network integration.

(2) Better convergence of voice, video, and data onto one networking infrastructure.

(3) Reduced ship life cycle costs and manning by employing IPv6 autoconfiguration.

(4) Better communications integration with allies, coalition forces, and the commercial Internet.

(5) More reliable and robust peer-to-peer and client/server communications.

The USN and DoD must begin planning for this transition to maintain the military's leadership in information technology. Our friends, allies, and adversaries have keen interest in this technology for Electronic Commerce and military applications. Many TCP/IPv6 enabled hardware and software products have finally come to market with many more coming in the near future. Now is the time to begin preparing for TCP/IPv6s application to Naval Engineering.

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\*   In the context of this paper, NGI is the next great evolution of the Internet as envisioned by the Internet Society (ISOC) when the TCP/IPv4 protocol family will be replaced by the TCP/IPv6 protocol family. It is not the federally sponsored NGI Initiative (NGII) for

research into advanced internetworking and communications technologies. NGII may utilize the TCP/IPv4 and TCP/IPv6 protocol families for it's research but this is outside the scope of this paper.

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